Replication Report: Zou(2022) Unwatched Pollution: The Effect of Intermittent Monitoring on Air Quality, AER

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2022-12-09

```
source(paste0(getwd(),"/Rcode/Rep_Urban.R"))
```

```
## Classes 'data.table' and 'data.frame':   77925 obs. of  55 variables:
##  $ State.Code                    : chr  "01" "01" "01" "01" ...
##  $ County.Code                   : chr  "003" "003" "003" "003" ...
##  $ Site.Num                      : chr  "0010" "0010" "0010" "0010" ...
##  $ Parameter.Code                : chr  "44201" "44201" "44201" "68101" ...
##  $ POC                           : chr  "1" "1" "1" "1" ...
##  $ Latitude                      : chr  "30.498001" "30.498001" "30.498001" "30.498001" ...
##  $ Longitude                     : chr  "-87.881412" "-87.881412" "-87.881412" "-87.881412" ...
##  $ Datum                         : chr  "NAD83" "NAD83" "NAD83" "NAD83" ...
##  $ Parameter.Name                : chr  "Ozone" "Ozone" "Ozone" "Sample Flow Rate- CV" ...
##  $ Sample.Duration               : chr  "1 HOUR" "8-HR RUN AVG BEGIN HOUR" "8-HR RUN AVG BEGIN HOUR"
##  $ Pollutant.Standard            : chr  "Ozone 1-hour Daily 2005" "Ozone 8-Hour 1997" "Ozone 8-Hour 1
##  $ Metric.Used                   : chr  "Daily maxima of observed hourly values (between 9:00 AM and
##  $ Method.Name                   : chr  "INSTRUMENTAL - ULTRA VIOLET" "" "" "Anderson RAAS2.5-300 PM1
##  $ Year                          : chr  "2001" "2001" "2001" "2001" ...
##  $ Units.of.Measure              : chr  "Parts per million" "Parts per million" "Parts per million"
##  $ Event.Type                    : chr  "No Events" "No Events" "No Events" "No Events" ...
##  $ Observation.Count             : chr  "5607" "5860" "5860" "116" ...
##  $ Observation.Percent           : chr  "99" "100" "100" "100" ...
##  $ Completeness.Indicator        : chr  "Y" "Y" "Y" "Y" ...
##  $ Valid.Day.Count               : chr  "243" "244" "244" "59" ...
##  $ Required.Day.Count            : chr  "245" "245" "245" "61" ...
##  $ Exceptional.Data.Count        : chr  "0" "0" "0" "0" ...
##  $ Null.Data.Count               : chr  "273" "0" "0" "0" ...
##  $ Primary.Exceedance.Count      : chr  "0" "2" "6" "" ...
##  $ Secondary.Exceedance.Count    : chr  "0" "2" "6" "" ...
##  $ Certification.Indicator       : chr  "Certified" "Certified" "Certified" "Certification not requi
##  $ Num.Obs.Below.MDL             : chr  "209" "0" "0" "0" ...
##  $ Arithmetic.Mean               : chr  "0.051687" "0.046201" "0.046201" "0.192241" ...
##  $ Arithmetic.Standard.Dev       : chr  "0.016349" "0.015035" "0.015035" "0.049609" ...
##  $ X1st.Max.Value                : chr  "0.095" "0.089" "0.089" "0.3" ...
##  $ X1st.Max.DateTime             : chr  "2001-05-15 16:00" "2001-05-15 14:00" "2001-05-15 14:00" "200
##  $ X2nd.Max.Value                : chr  "0.093" "0.087" "0.087" "0.3" ...
##  $ X2nd.Max.DateTime             : chr  "2001-06-25 15:00" "2001-06-25 10:00" "2001-06-25 10:00" "200
##  $ X3rd.Max.Value                : chr  "0.09" "0.081" "0.081" "0.3" ...
##  $ X3rd.Max.DateTime             : chr  "2001-05-14 18:00" "2001-05-16 09:00" "2001-05-16 09:00" "200
##  $ X4th.Max.Value                : chr  "0.087" "0.078" "0.078" "0.3" ...
##  $ X4th.Max.DateTime             : chr  "2001-07-14 14:00" "2001-05-14 11:00" "2001-05-14 11:00" "200
##  $ X1st.Max.Non.Overlapping.Value: chr  "" "" "" "" ...
```

```
##  $ X1st.NO.Max.DateTime          : chr  "" "" "" "" ...
##  $ X2nd.Max.Non.Overlapping.Value: chr  "" "" "" "" ...
##  $ X2nd.NO.Max.DateTime          : chr  "" "" "" "" ...
##  $ X99th.Percentile              : chr  "0.09" "0.081" "0.081" "0.3" ...
##  $ X98th.Percentile              : chr  "0.085" "0.078" "0.078" "0.3" ...
##  $ X95th.Percentile              : chr  "0.079" "0.071" "0.071" "0.3" ...
##  $ X90th.Percentile              : chr  "0.075" "0.066" "0.066" "0.2" ...
##  $ X75th.Percentile              : chr  "0.064" "0.057" "0.057" "0.2" ...
##  $ X50th.Percentile              : chr  "0.051" "0.045" "0.045" "0.2" ...
##  $ X10th.Percentile              : chr  "0.031" "0.027" "0.027" "0.1" ...
##  $ Local.Site.Name               : chr  "FAIRHOPE, Alabama" "FAIRHOPE, Alabama" "FAIRHOPE, Alabama"
##  $ Address                       : chr  "FAIRHOPE HIGH SCHOOL, FAIRHOPE,  ALABAMA" "FAIRHOPE HIGH SC
##  $ State.Name                    : chr  "Alabama" "Alabama" "Alabama" "Alabama" ...
##  $ County.Name                   : chr  "Baldwin" "Baldwin" "Baldwin" "Baldwin" ...
##  $ City.Name                     : chr  "Fairhope" "Fairhope" "Fairhope" "Fairhope" ...
##  $ CBSA.Name                     : chr  "Daphne-Fairhope-Foley, AL" "Daphne-Fairhope-Foley, AL" "Dapl
##  $ Date.of.Last.Change           : chr  "2013-07-20" "2013-07-20" "2013-07-20" "2010-03-05" ...
##  - attr(*, ".internal.selfref")=<externalptr>
```

```
## Warning in `[.data.table`(epa.master.PM10, , `:=`(a, as.numeric(get(a))), :
## with=FALSE together with := was deprecated in v1.9.4 released Oct 2014. Please
## wrap the LHS of := with parentheses; e.g., DT[,(myVar):=sum(b),by=a] to assign
## to column name(s) held in variable myVar. See ?':=' for other examples. As
## warned in 2014, this is now a warning.
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## to column name(s) held in variable myVar. See ?':=' for other examples. As
## warned in 2014, this is now a warning.
```

```
## 'data.frame':    300400 obs. of  30 variables:
##  $ State.Code           : chr  "01" "01" "01" "01" ...
##  $ County.Code          : chr  "001" "001" "001" "001" ...
##  $ Site.Number          : chr  "0001" "0001" "0002" "0002" ...
##  $ Parameter.Code       : chr  "11103" "42401" "42401" "44201" ...
##  $ Parameter.Name       : chr  "Benzene soluble organics (TSP)" "Sulfur dioxide" "Sulfur dioxide" "O
##  $ POC                  : chr  "1" "1" "1" "1" ...
##  $ Latitude             : chr  "32.437458" "32.437458" "32.428333" "32.428333" ...
##  $ Longitude            : chr  "-86.472891" "-86.472891" "-86.443611" "-86.443611" ...
##  $ Datum                : chr  "WGS84" "WGS84" "NAD27" "NAD27" ...
##  $ First.Year.of.Data   : chr  "1974" "1974" "1980" "1980" ...
##  $ Last.Sample.Date     : chr  "1974-06-10" "1976-08-16" "1982-07-31" "1982-09-30" ...
##  $ Monitor.Type         : chr  "" "" "" "" ...
##  $ Networks             : chr  "" "" "" "" ...
##  $ Reporting.Agency     : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ PQAO                 : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ Collecting.Agency    : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ Exclusions           : chr  "" "" "" "" ...
##  $ Monitoring.Objective : chr  "UNKNOWN" "HIGHEST CONCENTRATION" "UNKNOWN" "HIGHEST CONCENTRATION" .
##  $ Last.Method.Code     : chr  "091" "091" "020" "011" ...
##  $ Last.Method          : chr  "HI-VOL - BENZENE EXTRACTION-SOXHLET" "GAS-BUBBLER - PARAROSANILINE-SU
##  $ NAAQS.Primary.Monitor: chr  "" "" "" "" ...
##  $ QA.Primary.Monitor   : chr  "" "" "" "" ...
##  $ Local.Site.Name      : chr  "" "" "" "" ...
##  $ Address              : chr  "KING ARTHUR TRAILER COURT, PRATTVILLE,AL" "KING ARTHUR TRAILER COURT
##  $ State.Name           : chr  "Alabama" "Alabama" "Alabama" "Alabama" ...
##  $ County.Name          : chr  "Autauga" "Autauga" "Autauga" "Autauga" ...
##  $ City.Name            : chr  "Prattville" "Prattville" "Prattville" "Prattville" ...
##  $ CBSA.Name            : chr  "Montgomery, AL" "Montgomery, AL" "Montgomery, AL" "Montgomery, AL" .
##  $ Tribe.Name           : chr  "" "" "" "" ...
##  $ Extraction.Date      : chr  "2015-12-02" "2015-12-02" "2015-12-02" "2015-12-02" ...
## 'data.frame':    300400 obs. of  30 variables:
##  $ State.Code           : chr  "01" "01" "01" "01" ...
##  $ County.Code          : chr  "001" "001" "001" "001" ...
##  $ Site.Number          : chr  "0001" "0001" "0002" "0002" ...
##  $ Parameter.Code       : chr  "11103" "42401" "42401" "44201" ...
##  $ Parameter.Name       : chr  "Benzene soluble organics (TSP)" "Sulfur dioxide" "Sulfur dioxide" "O
##  $ POC                  : chr  "1" "1" "1" "1" ...
##  $ Latitude             : chr  "32.437458" "32.437458" "32.428333" "32.428333" ...
##  $ Longitude            : chr  "-86.472891" "-86.472891" "-86.443611" "-86.443611" ...
##  $ Datum                : chr  "WGS84" "WGS84" "NAD27" "NAD27" ...
##  $ First.Year.of.Data   : chr  "1974" "1974" "1980" "1980" ...
##  $ Last.Sample.Date     : chr  "1974-06-10" "1976-08-16" "1982-07-31" "1982-09-30" ...
##  $ Monitor.Type         : chr  "" "" "" "" ...
##  $ Networks             : chr  "" "" "" "" ...
##  $ Reporting.Agency     : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ PQAO                 : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ Collecting.Agency    : chr  "" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt" "Al Dept Of Env  Mgt"
##  $ Exclusions           : chr  "" "" "" "" ...
##  $ Monitoring.Objective : chr  "UNKNOWN" "HIGHEST CONCENTRATION" "UNKNOWN" "HIGHEST CONCENTRATION" .
##  $ Last.Method.Code     : chr  "091" "091" "020" "011" ...
##  $ Last.Method          : chr  "HI-VOL - BENZENE EXTRACTION-SOXHLET" "GAS-BUBBLER - PARAROSANILINE-SU
##  $ NAAQS.Primary.Monitor: chr  "" "" "" "" ...
##  $ QA.Primary.Monitor   : chr  "" "" "" "" ...
```

```
##  $ Local.Site.Name      : chr  "" "" "" "" ...
##  $ Address              : chr  "KING ARTHUR TRAILER COURT, PRATTVILLE,AL" "KING ARTHUR TRAILER COURT
##  $ State.Name           : chr  "Alabama" "Alabama" "Alabama" "Alabama" ...
##  $ County.Name          : chr  "Autauga" "Autauga" "Autauga" "Autauga" ...
##  $ City.Name            : chr  "Prattville" "Prattville" "Prattville" "Prattville" ...
##  $ CBSA.Name            : chr  "Montgomery, AL" "Montgomery, AL" "Montgomery, AL" "Montgomery, AL" .
##  $ Tribe.Name           : chr  "" "" "" "" ...
##  $ Extraction.Date      : chr  "2015-12-02" "2015-12-02" "2015-12-02" "2015-12-02" ...
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```
## Warning in `[.data.table`(entext.PM10, , `:=`(a, as.numeric(get(a))), with =
## FALSE): with=FALSE together with := was deprecated in v1.9.4 released Oct 2014.
## Please wrap the LHS of := with parentheses; e.g., DT[,(myVar):=sum(b),by=a] to
## assign to column name(s) held in variable myVar. See ?':=' for other examples.
## As warned in 2014, this is now a warning.
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## Warning in `[.data.table`(entext.PM25, , `:=`(a, as.numeric(get(a))), with =
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```

```
## Classes 'data.table' and 'data.frame':   18360 obs. of  17 variables:
##  $ State.Code            : chr  "01" "01" "01" "01" ...
##  $ County.Code           : chr  "049" "053" "055" "055" ...
##  $ Site.Num              : chr  "1002" "0002" "0008" "0008" ...
##  $ POC                   : num  1 1 3 4 1 1 4 1 2 1 ...
##  $ Year                  : num  2001 2001 2001 2001 2001 ...
##  $ Completeness.Indicator: chr  "N" "Y" "Y" "Y" ...
##  $ Valid.Day.Count       : num  52 59 53 53 57 59 364 61 51 57 ...
##  $ Required.Day.Count    : num  61 61 61 61 61 61 365 61 61 61 ...
##  $ Null.Data.Count       : num  9 2 8 8 4 1 0 0 9 4 ...
##  $ Arithmetic.Mean       : num  20.4 21.5 20 18.5 22.7 ...
##  $ X99th.Percentile      : num  52 50 50 41 58 91 115 105 104 73 ...
##  $ X98th.Percentile      : num  50 42 42 40 56 57 99 78 77 58 ...
##  $ X95th.Percentile      : num  50 40 39 38 42 52 84 57 57 49 ...
##  $ X90th.Percentile      : num  39 33 37 34 37 50 73 52 52 46 ...
##  $ X75th.Percentile      : num  24 26 26 23 28 40 49 40 39 35 ...
##  $ X50th.Percentile      : num  17 21 19 17 21 25 31 27 28 26 ...
##  $ X10th.Percentile      : num  7 11 8 9 11 12 13 15 15 13 ...
##  - attr(*, ".internal.selfref")=<externalptr>
## Classes 'data.table' and 'data.frame':   4665 obs. of  6 variables:
##  $ State.Code        : chr  "01" "01" "01" "01" ...
##  $ County.Code       : chr  "015" "033" "049" "053" ...
##  $ Site.Num          : chr  "0001" "1002" "1002" "0002" ...
```

```
##  $ POC               : num  1 1 1 1 1 2 3 4 1 1 ...
##  $ First.Year.of.Data: num  1990 1990 1990 1990 1985 ...
##  $ Last.Sample.Date  : chr  "1998-10-08" "1998-12-01" "2002-03-27" "2006-04-29" ...
##  - attr(*, ".internal.selfref")=<externalptr>
## Classes 'data.table' and 'data.frame':   27028 obs. of  19 variables:
##  $ State.Code           : chr  "01" "01" "01" "01" ...
##  $ County.Code          : chr  "053" "053" "053" "053" ...
##  $ Site.Num             : chr  "0002" "0002" "0002" "0002" ...
##  $ POC                  : num  1 1 1 1 3 3 4 4 4 1 ...
##  $ First.Year.of.Data   : num  1990 1990 1990 1990 1987 ...
##  $ Last.Sample.Date     : chr  "2006-04-29" "2006-04-29" "2006-04-29" "2006-04-29" ...
##  $ Year                 : num  2001 2002 2003 2004 2001 ...
##  $ Completeness.Indicator: chr  "Y" "Y" "Y" "Y" ...
##  $ Valid.Day.Count      : num  59 53 61 56 53 57 53 53 59 57 ...
##  $ Required.Day.Count   : num  61 61 61 61 61 61 61 61 61 61 ...
##  $ Null.Data.Count      : num  2 8 0 5 8 4 8 8 2 4 ...
##  $ Arithmetic.Mean      : num  21.5 20 20.2 18.6 20 ...
##  $ X99th.Percentile     : num  50 42 46 43 50 72 41 47 72 58 ...
##  $ X98th.Percentile     : num  42 38 41 35 42 55 40 39 70 56 ...
##  $ X95th.Percentile     : num  40 38 34 34 39 47 38 29 59 42 ...
##  $ X90th.Percentile     : num  33 35 31 28 37 36 34 26 37 37 ...
##  $ X75th.Percentile     : num  26 27 22 25 26 30 23 23 30 28 ...
##  $ X50th.Percentile     : num  21 19 19 18 19 20 17 16 20 21 ...
##  $ X10th.Percentile     : num  11 9 13 8 8 9 9 8 11 11 ...
##  - attr(*, "sorted")= chr [1:4] "State.Code" "County.Code" "Site.Num" "POC"
##  - attr(*, ".internal.selfref")=<externalptr>
## Reading layer `gisout_site_to_grid_cw' from data source
##   `D:\Dropbox\001_Data\AL_Urban\1_build\epa\proc\gisout_site_to_grid_cw.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 19420 features and 13 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -1.797693e+308 ymin: -1.797693e+308 xmax: 144.8716 ymax: 70.29222
## Geodetic CRS:  WGS 84
## Reading layer `gisout_grid_to_county_cw' from data source
##   `D:\Dropbox\001_Data\AL_Urban\1_build\usng\proc\gisout_grid_to_county_cw.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 111408 features and 14 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -179.3432 ymin: 17.84392 xmax: 179.8291 ymax: 71.40849
## Geodetic CRS:  WGS 84
## Reading layer `gisout_areaID_to_cbsa_cw' from data source
##   `D:\Dropbox\001_Data\AL_Urban\1_build\actday\proc\gisout_areaID_to_cbsa_cw.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 346 features and 13 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -123.8317 ymin: 27.8 xmax: -67.0592 ymax: 48.248
## Geodetic CRS:  WGS 84
## Reading layer `cb_2013_us_cbsa_5m' from data source
##   `D:\Dropbox\001_Data\AL_Urban\1_build\geo\cbsa_2013\cb_2013_us_cbsa_5m.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 929 features and 8 fields
```

```
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -160.2496 ymin: 17.92688 xmax: -65.58995 ymax: 65.45448
## Geodetic CRS:  NAD83
## Reading layer `cnty_cen2010' from data source
##   `D:\Dropbox\001_Data\AL_Urban\1_build\geo\county_2010\cnty_cen2010.shp'
##   using driver `ESRI Shapefile'
## Simple feature collection with 3221 features and 6 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -179.1473 ymin: 17.88481 xmax: 179.7785 ymax: 71.35256
## Geodetic CRS:  NAD83
```

```
## Warning in log(aod): NaNs produced
```

```
##
## Call:
## lm(formula = lnaod ~ factor(eday), data = master.dat, na.action = na.omit)
##
## Coefficients:
##   (Intercept)  factor(eday)2  factor(eday)3  factor(eday)4  factor(eday)5
##      -2.07399        0.04580        0.06949        0.01207        0.04481
## factor(eday)6
##       0.04453
##
##
## ================================================
##                         Dependent variable:
##                     ---------------------------
##                                  lnaod
## ------------------------------------------------
## factor(eday)2                0.046***
##                               (0.005)
##
## factor(eday)3                0.069***
##                               (0.005)
##
## factor(eday)4                0.012***
##                               (0.005)
##
## factor(eday)5                0.045***
##                               (0.006)
##
## factor(eday)6                0.045***
##                               (0.006)
##
## Constant                     -2.074***
##                               (0.002)
##
## ------------------------------------------------
## Observations                  391,376
## R2                             0.001
## Adjusted R2                    0.001
## Residual Std. Error     0.974 (df = 391370)
## F Statistic         50.988*** (df = 5; 391370)
```

```
## ================================================
## Note:                *p<0.1; **p<0.05; ***p<0.01
```

This paper is a replication report of Zou(2022), which shows the effect of intermittent monitoring of environmental standard on polluting activities. Among the results, this paper shows replication result of figure 2 in Zou(2022), which shows pollution gap between on-monitor day and off-monitor days.

Data Description

Monitor Data

PM monitor characteristics come from EPA's Air Quality System (AQS) for the years 2001 to 2013.

Satellite Data

Measure of atmospheric particle pollution (hereby "aerosol"). Data came from the National aeronautics and Space Administration (NASA) Moderate Resolution Imagining Spectroradiometer (MODIS) algorithm.